Call PIM- Progress In MPGDs

Call Project Proposal 2014
Commissione Scientifica Nazionale V
Pavia, 15 luglio 2014

Scientific Project Leader: Silvia Dalla Torre

	INFN unit	Unit Coordinator	components	FTE	Work Packages (WP) (with reference to section 2)
1	Bari	Ranieri Antonio	11	2.5	WP1, WP2
2	Bologna	Giacomelli Paolo	6	1.0	WP3
3	LNF	Bencivenni Giovanni	16	4.2	WP1, WP2, WP3, WP4
4	Mi-Bicocca	Gorini Giuseppe	8	2.5	WP2, WP4
5	Napoli	Della Pietra Massimo	7	1.3	WP1, WP3
6	Pavia	Riccardi Cristina	6	1.5	WP4
7	Roma 3	Iodice Mauro	3	0.5	WP1
8	Trieste	Dalla Torre Silvia	6	1.2	WP1
	Roma 1 (personal part.)	Pinci Davide	1	0.1	WP3
		Total	63	14.7	

Goals and working packages

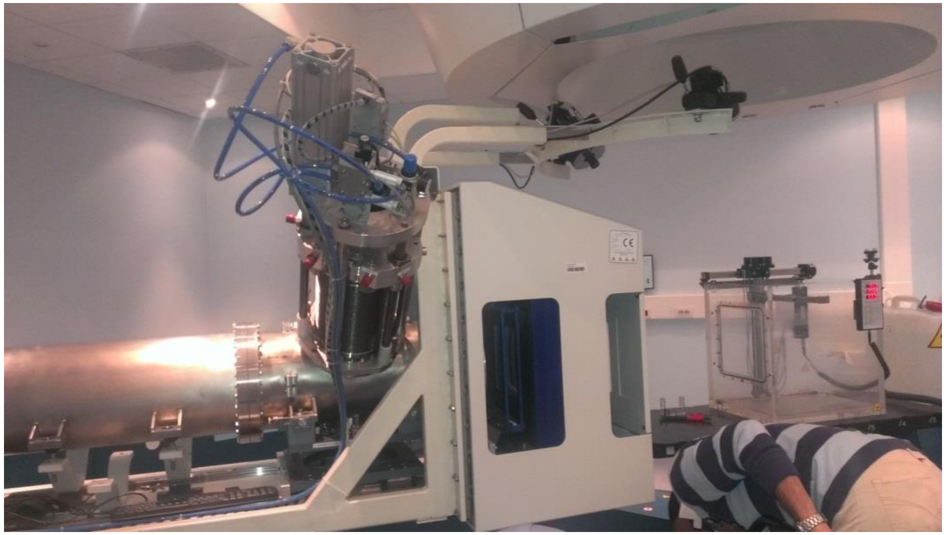
The goal of the three-year project denominated ***Progress In MPGDs (PIM)*** *is to establish key issues in the field of MPGDs resulting in relevant steps forward respect to the present state-of-the-art:*

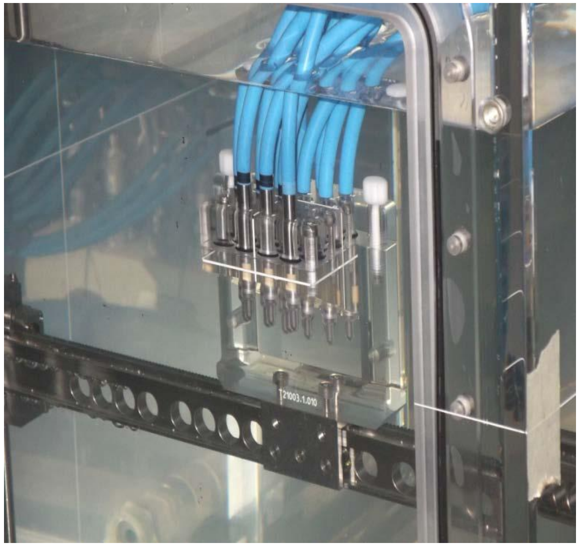
the development of four novel MPGD architectures with complementary features and outstanding characteristics, the development of two MPGD-dedicated read-out FE electronics with diversified characteristics in order to match specific requirements in the sector, the complementary technological developments, and the implementation of specific MPGD applications beyond HEP in the field of neutron detection and in the medical sector.

1. **Novel MPGD Architectures (G.Bencivenni)**
    1. R-WGEM
    2. Multi μgap-resistive well
    3. High performance MICROMEGAS
    4. High-gain hybrid MPGD
2. **MPGD-dedicated FE (A.Ranieri)**
    1. Digital FE
    2. Fast high density
3. **MPGD-dedicated technological developments (S.Bianco)**
    1. Streching & control systems
    2. High-performance eco friendly gas mixtures
4. **MPGD applications beyond HEP (F.Murtas)**
    1. **Beam monitor for medical application**
    2. Fast and thermal neutron detection

Development of a triple GEM device for the physical and dosimetric characterization of particle beams in hadrontherapy

- **state-of-the-art**: In the CNAO facility, the dosimetric system is able to host up to 24 pin-point ICs aligned in six rows in a way that none of them perturbs the other ones. The ionization chambers are inside a water phantom.





- **requirements**:
  - Size: 15x15 cm^2, according to the treatment plan requirements. → **High granularity time saving cost reduction**
  - good resolution
  - optimal radiation background control
  - good linearity and uniformity of the response

Sinergie

- Gruppo Ardent: F. Murtas et al
  - Sviluppo di tripla GEM (GEMPIX) per beam monitor

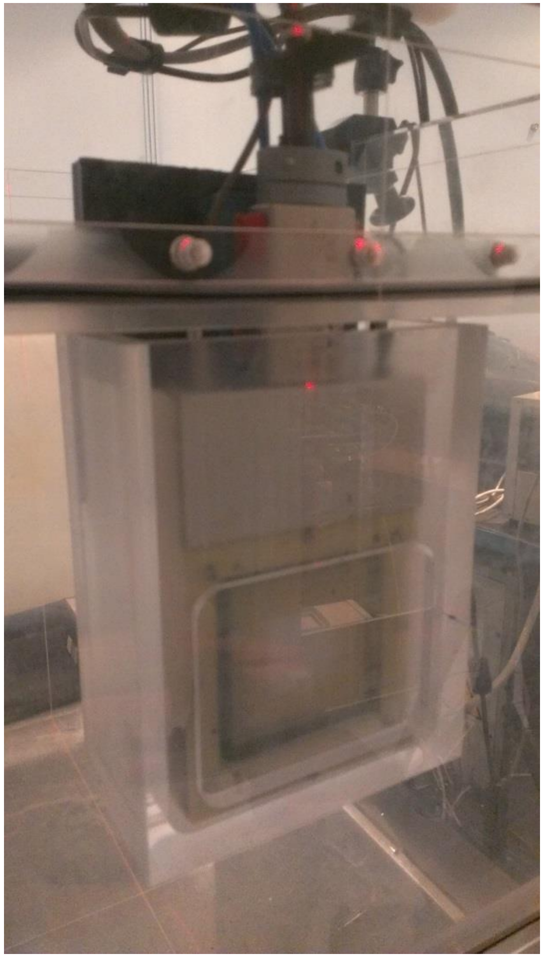
  con area attiva 2,8x2,8 cm^2 e pad 55 μm oppure GEM 10x10 cm^2 e pad di qualche mm..
  - Protoni e ioni C con e senza fantoccio

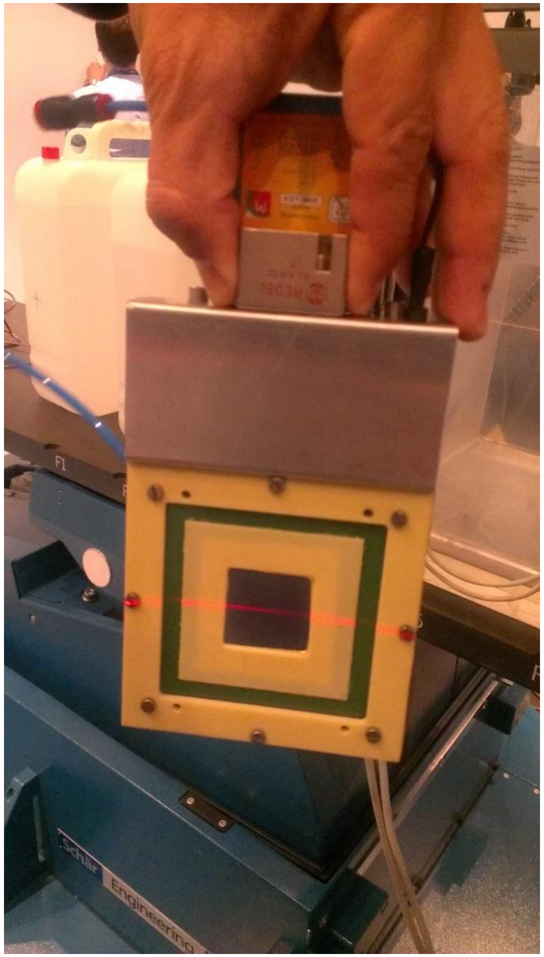
- LENA: flusso max termici 1.17 $x10^{10}$ cm^{-2} s^{-1} ; flusso veloci (En > 3 MeV) 9.4 10^4 $x10^{10}$ cm^{-2} s^{-1}, per En > 1.6 keV il flusso è $4.39x10^7$ cm^{-2} s^{-1}
  - valutazioni di effetti di neutroni secondari su rivelatore

- BTF –Frascati (Linac con frequenza di 50 impulsi al secondo e ~10^7-10^{10} particelle per impulso, in un range di energia di 300-750 MeV per gli elettroni e 300-550 MeV per i positroni)
  - detector occupancy e risposta a neutroni

- CNAO: max 10^{10} p per spill, $4x10^8$ C6+ per spill con energie tra 63 MeV e 250 MeV per p e tra 120 MeV/u e 400 MeV/u per ioni carbonio

Ardent setup at CNAO: Murtas et al.





GEMPIX:

Numero pixel: 512 x 512
Dimensione pixel: 55 µm x 55 µm
Lettura mediante la cosiddetta «Bluebox» (chip TIMEPIX 1)
Sezione QUADRATA

Viene messa all'interno di una box di PMMA con finestra frontale di 2 mm.
Sistemata nel fantoccio motorizzato riempito di acqua.
Fantoccio all'isocentro.

Ogni spill viene scansionato 43 volte. Le 43 slices vengono analizzate alla fine della misura→ no dead time → calcolo corretto numero di particelle → dose corretta

GEM:
Numero pixel: 128 x 128
Dimensione pixel: 2 mm x 2 mm
Lettura mediante chip CARIOCA ed FPGA (montato lontano dalla GEM per evitare esposizione sotto il fascio)
Sezione CIRCOLARE
Pad in rame dorato

La GEM è montata su di un cavalletto tripode e posta vicino al nozzle

Piano di Misure

- Characterization of the detector configuration and readout electronics : check of the linearity, uniformity and stability of the detector response, the gain calibration and the detection efficiency
  - Cosmic rays in CMS lab
  - Gamma/electron at the Beam Test Facility (Frascati)

- Study of effects on GEM of secondary neutrons from the CNAO primary beam. (LENA ,BTF)

- Measurements at CNAO with proton and carbon ion beams with and without water phantom.
- Preliminary energy calibrations to tune the electronics readout and the linearity of the detector response.

- All the measurements will be supported by **Geant4 simulations** focused on a detailed description of the GEM detector, positioned on the CNAO beam line with different phantom implementations.

- Comparisons with present detection techniques (ionization chambers).

Anagrafica Pavia

Nome	FTE
Ferrari Roberto	20%
Riccardi Cristina	20%
Rimoldi Adele	10%
Salvini Paola	20%
Tamborini Aurora	50%
Vitulo Paolo	30%

Totale 1.5 FTE

Project Timeline PV

task 4.1 PAVIA	2015				2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
simulations of beam delivery line for the beam profile definition at the irradiation position												
study of the optimal readout granularity												
characterization of existing GEM prototypes												
measurements with existing prototypes of the dose profile uniformity												
development of a new detector												
characterization of the new detector: simulations, measurements with X-ray source												
test in laboratory with cosmic rays												
neutron sensitivity studies												
measurements at CNAO with protons and carbon ions												

Milestones

4	4.1	beam monitoiring for medical applications	the triple GEM detector for dose profile measurements	2016-Q3	report: triple GEM performance at CNAO

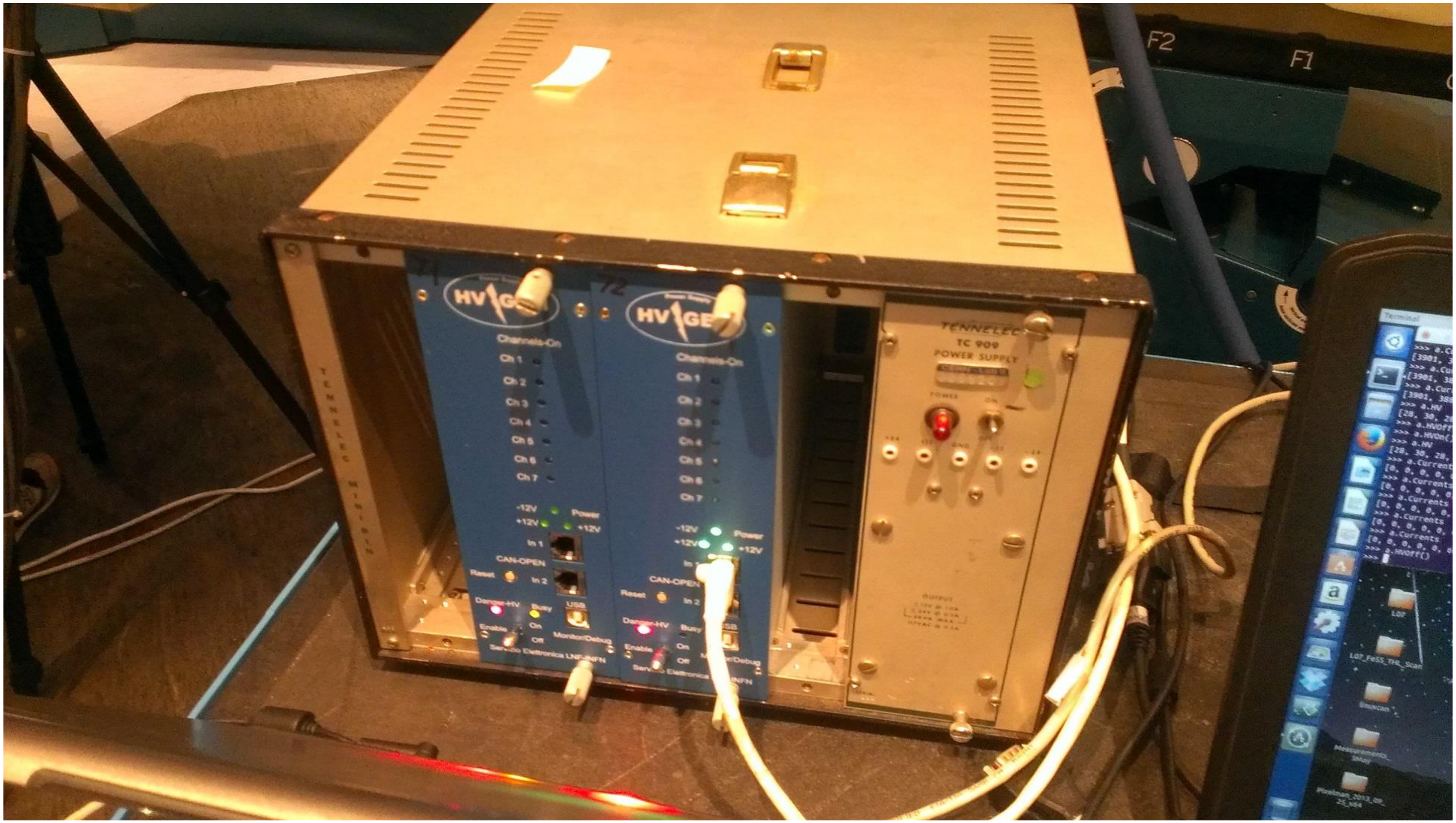
Preventivi

		INFN unit PAVIA				
		Year	2015	2016	2017	Total
Consumables						
	two GEM prototypes (small and large)		10	5		15
	setup at CNAO			10		10
	targets for measurements with neutrons			2		2
	neutrons irradiation			2		2
	laboratory consumables		6	6	5	17
	protons and ions irradiation				10	10
Equipments	HV GEM		4			4
	readout electronics		5	10		15
	phantom		15			15
						0
						0
Travelling						
	PIM annual meeting		1	1	1	3
	material procurement (GEM and readout integration)		1	1		2
	test beam (BTF)				5	5

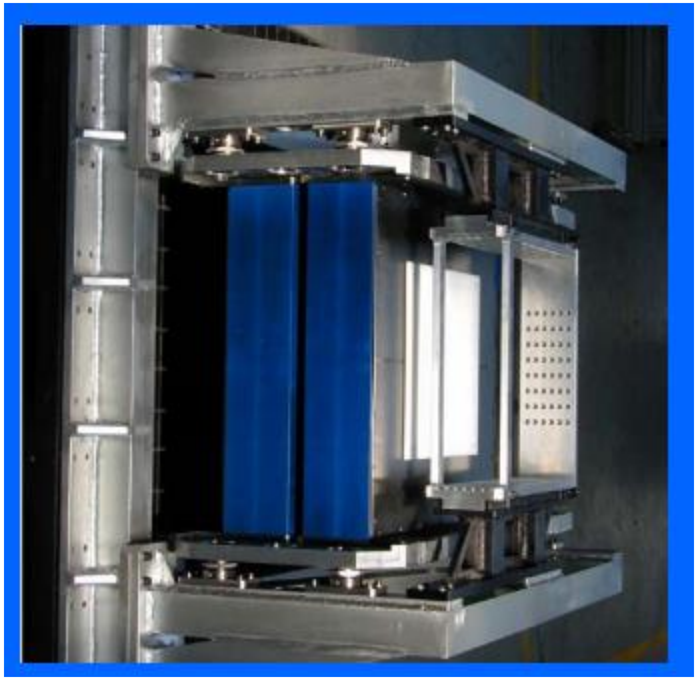
2015 → Consumables: 16K - Equipments: 24K – Travelling 2K

Richieste Servizi 2015: Officina Meccanica 1mu - Elettronica 1mu

backup



Channels-On
Ch 1
Ch 2
Ch 3
Ch 4
Ch 5
Ch 6
Ch 7
-12V
+12V
Power
+12V
In 1
CAN-OPEN
Reset
In 2
Danger-HV
Busy
USB
Enable
On
Off
Monitor/Debug
Servizio Elettronica LNF-INFN
TENNELEC
TC 909
POWER SUPPLY
F2
F1



Box 1 and box 2:

- 2 large-area integral chambers (fluence measurement)
- 2 strip chambers (spot position)
- 1 pixel chamber (fluence and position)

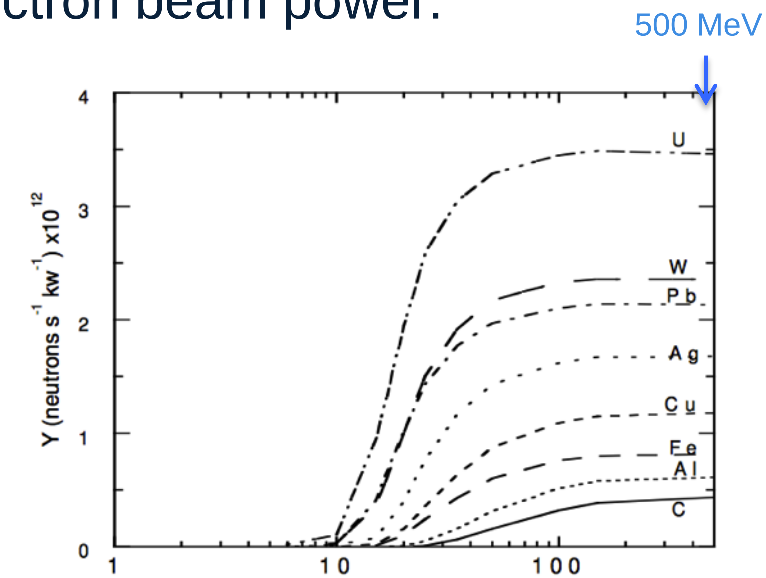
BTF neutrons

- Number of neutrons proportional to the electron beam power:

  P = rate×energy =[N×f]×E

  - N = number of particles per bunch (let's consider 1
  - f = frequency (up to 49 Hz)
  - E = beam energy (usually 510, up to 800)

  Maximum power: 40 W at 510 MeV



- From Swanson's empirical formula
  - 10^{11} n/s for Tungsten
  - -20% on Lead, +50% on Uranium

With 1.1×10^{11} n in the target:

- 8.8×10^{8} n/cm²/s exiting from the target
- 1.87×10^{10} γ/cm²/s exiting from the target

d (m)	$\times10^{-7}$ n/cm²/pr
0.5	58
1	15
1.5	8

d (m)	$\times10^{-5}$ γ/cm²/pr
0.5	63
1	5.7
1.5	1

At 1.5 m distance:

Total neutron flux: 8×10^{-7} n/cm²/pr ±3%

Flux = **4.5×10^{5} n/cm²/s**

Equivalente dose = 45 mSv/h

At 1.5 m distance

Total photon flux = 1×10^{6} γ/cm²/s

Isolethargic fluence

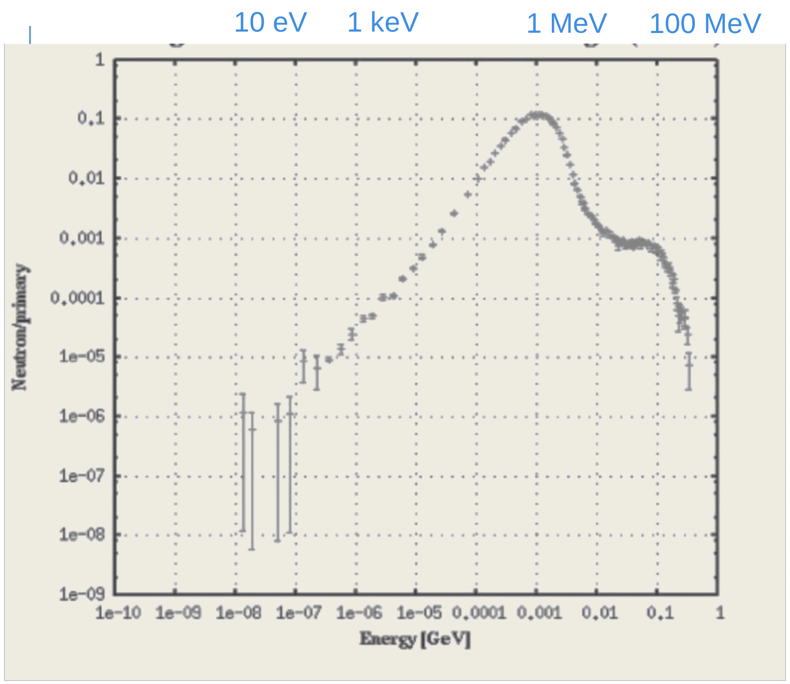


Table 2. DAΦNE BTF Electron, positron, gamma, neutron beam characteristics.

Operation mode	Electrons positrons	Gammas	Neutrons
Energy range [MeV]	25-500 25 – 750 (*)	100-500 100-750(*)	10^{-9}-200
Repetition rate [Hz]	20 – 49 49 (*)		
Pulse duration [ns]	10 1 or 10 (*)		
Multiplicity	1 up to 10^5 1 up to 10^{10}		4.9 10^{-5} n/cm2/electron
Duty cycle [%]	~ 80% ~ 96 % (*)		~ 40% ~ 96% (*)
Spot size ($\sigma_x x \sigma_y$) [mm]	~ 2×2 ~ 5.5x5.5	>20	-
Divergence [mrad]	~ 1 - 1.7	> 15	-
Energy resolution	< 1%	7%	-